EXHIBIT 20

MANAGERIAL ECONOMICS

THIRD EDITION

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that one must look carefully at the structure of the relation being estimated and be on the lookout for simultaneously determined variables.

OTHER PROBLEMS Finally, it is important to recognize that the regression approach depends on certain assumptions about randomness. To be explicit, let us rewrite Equation 4.1 as

$$Q = a + bP + cP^{\circ} + dY + \epsilon. \qquad [4.12]$$

Here, we have added the term ϵ. This is a random term that indicates that the values of the dependent variable are determined by the independent variables plus some randomness. The statistical properties of regression come from the assumptions one makes about the random term, ϵ. The key assumption is that this term is normally distributed with a mean of zero and a constant variance and that it is completely independent of everything else. If this assumption is violated, regression equations estimated by ordinary least squares will fail to possess some important statistical properties. Modifications to the OLS procedure must be made to estimate a correct equation having desirable statistical and forecasting properties.

Two main problems concerning random errors can be identified. First, **heteroscedasticity** occurs when the variance of the random error is nonconstant over the sample. A simple way to track down this problem is to look at the errors that come out of the regression: the differences between actual and predicted values. We can, for example, divide the errors into two groups, one associated with high prices and one with low prices, and find the sum of squared errors for each subgroup. If these are significantly different, this is evidence of heteroscedasticity.

Serial correlation occurs when the errors run in patterns, that is, the distribution of the random error in one period depends on its value in the previous period. For instance, the presence of positive correlation means that prediction errors tend to persist: Overestimates are followed by overestimates and underestimates by underestimates. There are standard statistical tests to detect serial correlation (either positive or negative). The best-known test is based on the **Durbin-Watson statistic** (which most regression programs compute). A value of approximately 2 for this statistic indicates the absence of serial correlation. Large deviations from 2 (either positive or negative) indicate that prediction errors are not random. The regressions reported for air-travel demand are free of serial correlation and heteroscedasticity.

Choosing a Regression Equation

Demand estimation is as much an art as a science. This chapter has presented many of the most important statistical techniques currently available.

But these techniques themselves never can be the final arbiter of the quality of demand equations and forecasts. Judgment plays as important a role as statistics in evaluating demand equations. Thus, the evaluation of an estimated demand equation depends on the answers to a number of important questions.

1. Does the equation (or equations) make economic sense? What is the underlying economic relationship? Are the "right" explanatory variables included in the equation? Might other relevant variables be included? What form of the equation is suggested by economic principles?
2. Are the signs and magnitudes of the estimated coefficients reasonable? Do they make economic sense?
3. Based on an intelligent interpretation of the regression statistics, does the equation have explanatory power? How well did it track the past data? What factors are most important in determining quantity demanded?

If the equation successfully answers the questions posed above, the manager can be confident that it embodies an accurate depiction of demand.

Predicting Presidential Elections Revisited

Consider, once again, the drug-company CEO's interest in predicting the upcoming presidential election. There have been two customary ways of devising such forecasts. One approach relies on polling. A common question might be: "If the presidential election were held today, would you vote for the Republican candidate, or the Democratic candidate?" Such polls provide valuable information, but are subject to the same response errors and biases of other surveys. Moreover, because likely candidates are known only six to eight months before the election, these predictions are necessarily very short term. A second approach is to make forecasts based on voting patterns from past elections. The most sophisticated models examine the past voting records state by state and combine this with an assessment of current party strength based on polls and incumbency considerations. (Historically, Utah and Idaho have had the strongest tendency to vote Republican, Arkansas and Rhode Island to vote Democratic.)

In striking contrast to these traditional methods, economic models recently have been adapted and applied to election forecasting. The idea is to incorporate key economic indicators as determinants of voter demand. The forecasting formula of Professor Ray Fair of Yale University has received considerable attention in the business press because it invokes a basic political tenet—that Americans vote their pocketbooks. The Fair equation predicts the percentage of the popular vote for the incumbent party based on only two economic variables: the rate of